Coordinating Earth Observing System Land Validation

Administration's (NASA's) Moderate Resolution Imaging Spectroradiometer (MODIS) land product validation project, initiated prior to the launch of the NASA Earth Observing System (EOS) Terra platform in late 1999, provides data, instrument, and information resources for the validation of products that quantify land surface characteristics from MODIS and other satellite sensors. Land prod-

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ucts derived from MODIS and other moderate-resolution sensors include, among others, land cover, snow cover extent, surface temperature, leaf area index, fire occurrence, and vegetation productivity.

The land validation project infrastructure, developed at NASA's Goddard Space Flight Center (GSFC), involves an integration of NASA-funded researchers, international collaborators, and science data networks. These resources facilitate determination of product uncertainty, which is the definition of validation, through best practice methods.

Key to the project is the set of EOS Land Validation Core Sites, a global network of 33 sites (including six added in 2006), which serve as a focus for validation activities. The initial infrastructure and activities were described in *Morisette et al.* [1999], *Justice et al.* [2000] and *Morisette et al.* [2002].

The present article provides an update on two components of the project: delivering validation status information on MODIS land products and providing Core Site data and information (Figure 1).

MODIS Land Team Validation Information and Core Site Infrastructure

The primary objective of the MODIS Land Team validation activities is to provide quantitative assessment of land product accuracy.

On the Land Validation Web site (http:// landval.gsfc.nasa.gov), summarized product accuracy information is given in a validation status page for each product. Each product status page provides a brief validation statement and a list of reference material, each element of which is linked to its own subsequent page with a full reference. an abstract, and sample results (usually figures or tables). Much of the supporting material for the product accuracy statements has been generated from data and fieldwork

conducted at Core Sites.

Though designed to support MODIS land product validation, the Core Site data and infrastructure provide a valuable resource that has been useful to researchers through-

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out EOS and other satellite and science programs. By design, many of the Core Sites are part of larger field networks (see Data Network section of Table below). While the Land Validation Web pages are managed at GSFC, the data offered via these pages are part of a distributed system supported by multiple data centers (see legend for Figure 2) that provide free public access to a wealth of Core Sites data and information. From the Land Validation home page, one can easily navigate to any one of the Core Sites pages.

Within a Core Site page, basic site information is followed by categorized data sets available for download (see Figure 1); most of the available data sets are listed in Figure 2.

Within the Satellite Data category are links to up to 15 satellite data sets. Currently, there are 135 Enhanced Thematic Mapper Plus (ETM+) scenes, 106 Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) acquisitions, and 67 IKONOS scenes for the 33 sites. Further, MODIS product subsets (200 kilometer × 200 kilometer) over Core Sites have been posted online since 2000. Multi-Angle Imaging Spectroradiometer (MISR) data subsets are also available from 2000 forward; Advanced Very High Resolution Radiometer (AVHRR) Normalized Difference Vegetation Index (NDVI) composite subsets from 1981 forward, and Systeme Prohatoire pour l'Observation de la Terre (SPOT) NDVI composite subsets from 1988 forward.

The Field, Tower, and Airborne Data category includes links to Aerosol Robotic Network (AERONET) data, Flux Network (FLUXNET) tower data, airborne data sets, digital photography, and other field data sets. The Ancillary Layers and Background Information category includes geographic information on most Core Sites as developed by the University of Maryland (UMD). This section also includes a land cover geostatistical analysis, and links to related Web pages.

Since the initiation of Core Site data distribution via the MODIS Land Validation web pages, users have downloaded more than 500 gigabytes of data. The physical location of the data is distributed to the most efficient and practical storage location. Although most of the satellite data are hosted at the Land Processes (LP)- Distributed Active Archive Center (DAAC), there are also data hosted at GSFC, the Oak Ridge National Lab (ORNL) and Langley DAACs, and some smaller data sets and digital photography hosted at investigator sites.

Additions to Core Site Data Holdings

Significant additions to Core Site resources, since publication of Morisette et al. [2002], include the following:

* NASA GSFC, in conjunction with the University of Maryland, has utilized aerosol optical property data (available through AERONET [Holben et al., 1998]) and the Second Simulation of the Satellite Signal in the Solar Spectrum (6S) modeling software [Vermote et al., 1997] to atmospherically correct 60 kilometer × 60 kilometer subsets extracted from 44 Landsat ETM+ scenes over 14 Core Sites [Morisette et al., 2004].

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* The GSFC Global Inventory Modeling and Mapping Studies (GIMMS) group has provided Core Sites subsets of its AVHRR NDVIg data, an 8-kilometer, bimonthly maximum-NDVI composite time series since 1981 [Tucker et al., 2005].

* The GIMMS group also has provided subsets of the 1-kilometer-resolution NDVI data from the SPOT VEGETATION instrument. These NDVI composites were created by selecting pixels of maximum NDVI from successive 10-day periods starting in mid-1998. There are plans to extend both sets of GIMMS NDVI subsets annually.

* Subsets of the National Elevation Dataset (NED), and digital terrain elevation data (DTED)-2, derived from the Shuttle Radar Topographic Mission (SRTM), have been extracted for the Core Sites and are available in two projections. The DTED were processed by NASA's Jet Propulsion Laboratory and the National Geospatial-Intelligence Laboratory and are available for all Core Sites. The NED is produced by the U.S. Geological Survey and is available for Core Sites within the United States only.

A new interactive Satellite View link follows the site name at the top of each Core Site page, and links to ETM+ and SRTM mosaics are available in the top right corner. FLUXNET links now appears within the Field, Tower, and Airborne Data category for the Core Sites within this network. FLUXNET coordinates regional and global analysis of observations from micrometeorological tower sites. Links to MODIS Land product subsets (7 kilometer × 7 kilometer) in ASCII format from the ORNL-DAAC are listed under the Satellite Data category, where new links to MISR subsets, provided by the Langley DAAC, are also included.

Future Directions

The MODIS Land Validation Web pages provide access to accuracy statements and supporting material for the MODIS land products and easy access to multiple satellite, airborne, and ground data sets. Most data are freely available online. The efficiency of reusing reference data for the various studies was facilitated by our coordination efforts and the established Core Site infrastructure. These data have many uses in remote sensing, ecology, land use and land cover change, and climate change studies.

Maintaining this validation resource will allow future missions, such as the National Polar-Orbiting Operational Environmental Satellite System, to capitalize on NASA's EOS pathfinding. To that end, we are investigating opportunities to further coordinate EOS Core Sites with long-term observing networks such as the National Oceanic and Atmospheric Administration's Climate Reference Network (CRN), which will provide sub-hourly field data for a nominal 50-100 year period. It is

also envisioned that the EOS Core Sites will become the backbone of an international network of core sites sponsored by the Committee for Earth Observing Satellites.

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References

Holben, B. N., et al. (1998), AERONET: A federated instrument network and data archive for aerosol characterization, *Remote Sens. Environ.*, 66(1), 1–16. Justice, C., A. Belward, J. Morisette, P. Lewis, J. Privette, and F. Baret (2000), Developments in the validation of satellite products for the study of the land surface, *Int. J. Remote Sens.*, 21(17), 3383–3390.

Morisette, J. T., J. Nickeson, C. Santos, E. Vermote, and J. Pedelty (2004), Atmospherically corrected Landsat ETM+ imagery for the EOS Land Validation Core Sites, *Earth Obs.*, *16*(5), 15–17.

Morisette, J., J. Privette, C. Justice, D. Olson, J. Dwyer, P. Davis, and D. Starr (1999), The EOS land validation core sites: Background information and current status, *Earth Obs.*, 11(6), 21–26.

Morisette, J., J. L. Privette, and C. Justice (2002), A framework for global land product validation, *Remote Sens. Environ.*, 83, 77–96. Tucker, C. J., J. E. Pinzon, M. E. Brown, D. A. Slayback,

E. W. Pak, R. Mahoney, E. F. Vermote, and N. El Saleous (2005), An extended AVHRR 8-km NDVI dataset compatible with MODIS and SPOT vegetation NDVI data, *Int. J. Remote Sens.*, 26(20), 4485–4498. Vermote, E. F., D. Tanre, J. L. Deuze, M. Herman, and

J. J. Morcrette (1997), Second simulation of the satellite signal in the solar spectrum, 6S: An overview, *IEEE Trans. Geosci. Remote Sens.*, 35(3), 675–686.

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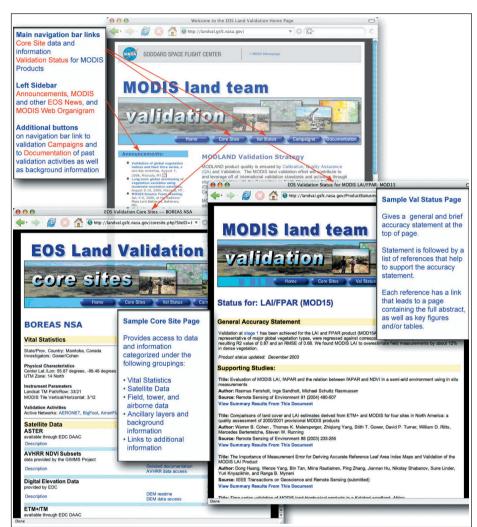


Fig. 1. Diagram of Web access to (top) main validation page, (left) sample Core Sites data access page, and (right) a sample MODIS product validation status page.

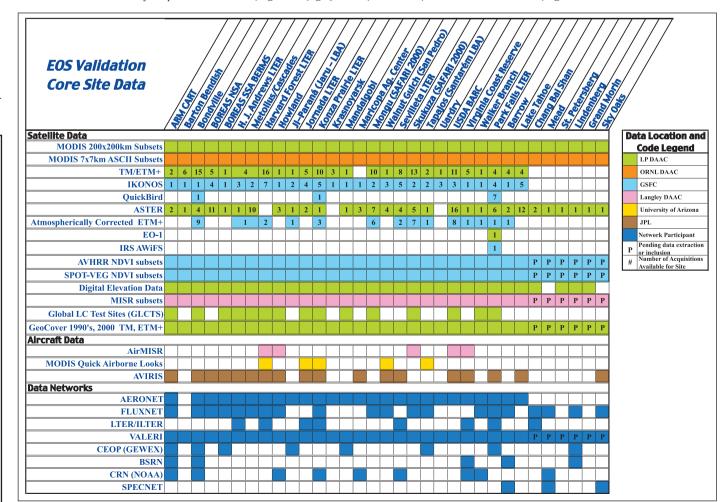


Fig. 2. Summary of Core Site data availability. Colored areas indicate where data are available. Numbers within boxes indicate the number of acquisitions for given site.